Response

Reply to Letter by Fann, Lamson, Anenberg, and Hubbell, Regarding Fraas & Lutter Article: "Uncertain Benefits Estimates for Reductions in Fine Particle Concentrations"

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In commenting on our article, "Uncertain Benefits Estimates for Reductions in Fine Particle Concentrations,"[1] Fann, Lamson, Anenberg, and Hubbell[2] argue that the central premise—that the Agency has done too little to respond to the 2002 National Research Council (NRC) Report[3]—is not supported by the historical record. Our article focused on the steps that EPA has taken to improve its estimation and characterization of health benefits and uncertainty since 2002, not in the abstract, but against the benchmark of the standard for quantitative uncertainty analysis called for by the NRC more than 10 years ago. Fann *et al.* supply no evidence to support their claim that we understated EPA's limited progress toward meeting that standard.

EPAs uncertainty analysis in its recent regulatory impact analyses (RIAs)—including the recent final RIA for the $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS)[4]—is largely unchanged from the approach reviewed and critiqued by the 2002 NRC Report and cannot be seen as evidence of adequate progress towards the standard of that report. EPA's recent RIAs provide two primary estimates of mortality benefits using two recent epidemiological studies based on data from the American Cancer Society and the Six City Study. These primary estimates include confidence intervals based on a Monte Carlo analysis using distributions reflecting the standard errors for the PM-mortality concentration–response (C–R) relationships from the two epidemiological studies and a distribution for the valuation of a reduction in the risk of premature mortality. These RIAs acknowledge—consistent with the critique of

the 2002 NRC Report[3]—that the Monte Carlo uncertainty analysis along with the alternative estimates developed from EPA's expert elicitation do not reflect other inherent sources of uncertainty. They state that: "As a result, the reported confidence intervals and range of estimates give an incomplete picture about the overall uncertainty in the estimates. This information should be interpreted within the context of the larger uncertainty surrounding the entire analysis"[4] (pp. 5–16).

EPA's RIAs also continue to include some additional sensitivity analyses exploring a few elements affecting premature mortality—for example, the effect of lag structure and discount rate on the benefit estimates and the sensitivity of the PM-related mortality benefit estimates to alternative income elasticity assumptions.[1] EPA finds these factors generally make only a limited contribution to uncertainty in the monetized benefits.[4]

Finally, EPA's RIAs continue to provide a separate qualitative discussion of some of the key assumptions underlying the estimates of premature mortality. In its recent PM NAAQS RIA, this discussion includes: the default assumption that all particulates are equally toxic, the shape of the C–R function for premature mortality (particularly at low concentrations), and uncertainty in air quality estimates.[2,4] The bottom line is that EPA has not pulled together

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[1] Sensitivity analyses of the lag structure and discount rate were included in the RIAs reviewed by the 2002 NRC Report.

[2] Appendix B of the PM NAAQS RIA describes the potential magnitude of the effects of these important assumptions on the benefit estimates as follows: the assumption that all PM are equally toxic as high, the shape of the C–R function as medium-to-high, and the uncertainty in air quality estimates as unknown[5] (Tables 5.B-1, 5.B-6 to 5B-14).

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an integrated quantitative uncertainty analysis as recommended by the 2002 NRC Report. Instead, these RIAs continue to provide a core primary analysis with truncated confidence intervals, a disparate set of sensitivity analyses coupled with a qualitative discussion of key uncertainties in their analysis. This "uncertainty" analysis often serves to obscure overall uncertainty in benefits, rather than to provide policymakers and interested readers with an integrated picture of the uncertainties in the EPA estimates.

Fann *et al.* state that we build our "uncertainty analysis largely upon assumptions that are not well grounded in the peer-reviewed literature." They do not note any specific deficiencies with the peer-reviewed articles we cite, such as Aldy and Viscusi[5] and Lindhjem *et al.*,[6] or our interpretation of these articles. They level three specific complaints.

- Regarding the valuation of mortality risk reduction, Fann *et al.* state that the EPA SAB[7] recommended that estimates from both types of studies be used in estimating benefits and suggest that our approach represents an "unreasonable treatment of uncertainty." Fann *et al.*, however, do not acknowledge support in the SAB letter for our approach. The SAB[7] states that "values for risk reductions are not 'one size fits all' and endorses the Agency's proposal to apply different values to different type of risk contexts." The SAB also recommends that EPA work toward "developing a set of estimates of the value of [mortality] risk reduction corresponding to policy-relevant contexts defined by the type or characteristics of the risk (e.g., associated morbidity, latency) and of the affected population (e.g., age, health, income)." Our approach, while also presenting EPA's valuation for mortality risk reduction as a base case, excludes estimates of the value of mortality risk reduction derived from hedonic wage studies (i.e., valuation for healthy middle-age workers), and reflects a key characteristic of the risk, which is that it primarily affects the elderly. The EPA's RIA for its recent final rule on $PM_{2.5}$ reports that roughly three-quarters of all avoided premature deaths are for people aged 65 and, of the remainder, half are for people 55 and over[4] (pp. 5–80). It also acknowledges that there is "considerable uncertainty" as to whether the available literature on the value of mortality risk reduction provides adequate estimates for risk reductions from air pollution.

The RIA notes that most of the studies examine differences in wages of risky occupations. It acknowledges that the appropriateness of a distribution of values for mortality risk reduction depends on the extent to which the risk being valued and the subjects being studied are similar to the population affected by changes in air pollution. It also notes recent research that "suggests that [the value of mortality risk reduction] based on hedonic wage studies may overstate the average value of a risk reduction"[4] (pp. 5–58). EPA's RIA then follows conventional EPA practice regarding mortality risk reduction—it ignores this information in estimating benefits. Our approach is more consistent with the SAB recommendations, and endeavors to implement them in a straightforward and transparent manner.

- Regarding a threshold, Fann *et al.* imply that we ignore "a great deal of evidence that there is a no-threshold, concentration–response relationship, including a review by the EPA's Clean Air Scientific Advisory Committee." In fact they offer no substantive comment either on our discussion, or on interesting and pertinent research that CASAC did not review because it was published after CASAC's deliberations.[3] We reject the suggestion by Fann *et al.* that CASAC's views should be seen as correct regardless of subsequent work. Further, EPA's RIA for the $PM_{2.5}$ NAAQS acknowledges less confidence in the estimated number of premature deaths from fine particles at locations with lower ambient concentrations. Specifically, it indicates that about 214 out of a total reduced mortality incidence of 460 (based on Krewski *et al.*[9]) occur at concentrations at or below 11 $\mu g/m^3$, that is, one standard deviation below the mean concentration (pp. 5–83). EPA acknowledges that confidence in the estimated number of premature deaths avoided diminishes when estimating impacts in locations where $PM_{2.5}$ levels are one standard deviation below the mean and lower. But its uncertainty analysis does not reflect this diminished confidence numerically; our approach provides one way of incorporating this uncertainty.

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[3] Greven *et al.*[8] report no association between measured fine particle concentrations and mortality when they use "local" estimators less likely to be subject to unknown confounding.

- Regarding the composition of PM, Fann *et al.* argue that our modeling does not appear to account for changes in PM composition. Our article provided results for two alternative scenarios that we believe reflect possible regulatory approaches. For example, EPA's recent final $PM_{2.5}$ NAAQS RIA projected that reductions in fine PM from combustion-related activity would be sufficient to achieve attainment of the new NAAQS in California; EPA's recent Cross State Air Pollution Rule $(CSAPR)^{[10]}$ required reductions in SO_2 and NO_x emissions from electric utility boilers through a cap-and-trade program.[4,11] If the projected reductions come from reductions in combustion-related fine PM, then the benefit estimates based on a "high-toxicity" C–R function would be an appropriate scenario; conversely, the "low-toxicity" C–R function would be applied to the RIA for a rule like CSAPR, which focuses on SO_2 and NO_x reductions.

We appreciate the interest by Fann *et al.* in our work and look forward to future concrete steps by EPA to implement the recommendations made by the NRC in 2002.

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